ENGINEERING CASE LIBRARY

ECL-51

Travaglio Engineering Co.

Manufacturing Design for a Cycle Timer

Mr. Dalny Travaglio, consulting design engineer, has developed and tested the conceptual design for a high accuracy, high repeatability cycle timer. This case presents the information required for carrying out the final mechanical design of the timer and is intended as an exercise in design for mass manufacture.

Prepared in the Design Division of the Department of Mechanical Engineering, Stanford University, by Professor Robert E. Keller with support from the National Science Foundation. Reproduced in the Engineering Case Program at Stanford University, Stanford California.

The need for a new, more accurate and repeatable cycle time arose when a firm employing Mr. Travaglio was asked to produce an automatic chemical processor. The particular processes involved were extremely sensitive to time and it was found that the timers which were commercially available did not give satisfactory performance. The needed timers had to perform the simple task of closing an electrical circuit for the specified amount of time with a cycle repeat accuracy of better than 1%. During the time the circuit was closed, the process was allowed to proceed. When the timer opened the circuit, valves acted and the process was terminated.

In testing the available timers for this application, Mr. Travaglio found that their performance was inherently limited by the principle on which the majority were based. In most of these, a mechanical clutch was used to engage a screw and a synchronous motor to provide the cycle and to engage a spring to reset the cycle. With the screw engaged, a threaded rider moved toward an electrical push-type switch at a fixed rate. Depending on the distance at which the switch had been located from the original position of the rider, the time interval before the switch was thrown was made to vary. Mechanical play in the parts made it impossible to reset the time interval with the necessary degree of accuracy.

Mr. Travaglio felt that the problems of the existing timers could be overcome if an "out-and-back" principle were adopted. With such an arrangement, the errors due to mechanical play would compensate themselves. Also, there would be no need to reset such a device before starting another cycle, since the beginning and ending position of the rider would be identical.

The rough schematic arrangement of the new timer is indicated in Figure 1. At the beginning of the timer action, the rider would be stationary at the left end. When the timer was started, the motor would turn the screw and the rider would move toward the right. When the rider reached the "reverse switch" and depressed its contact, the motor would be reversed and the rider would start back to the left.

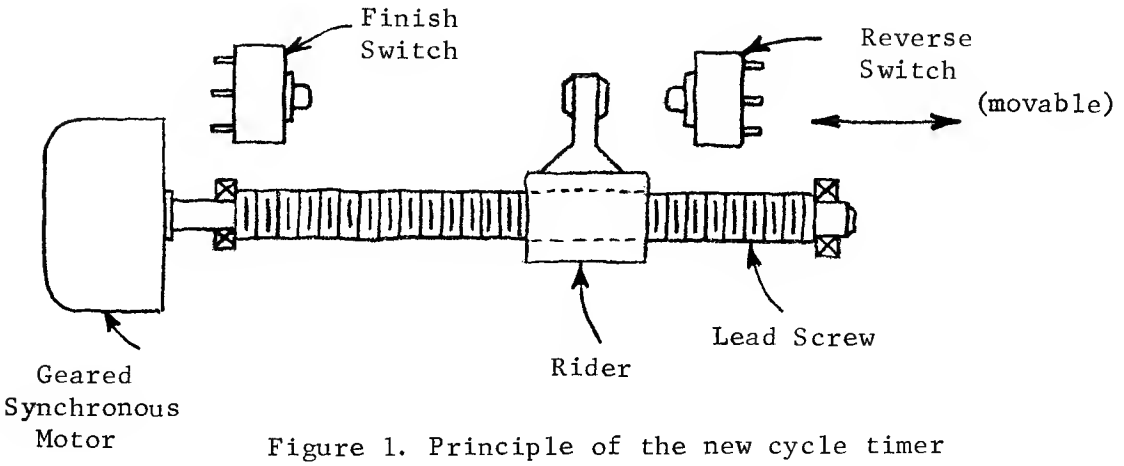
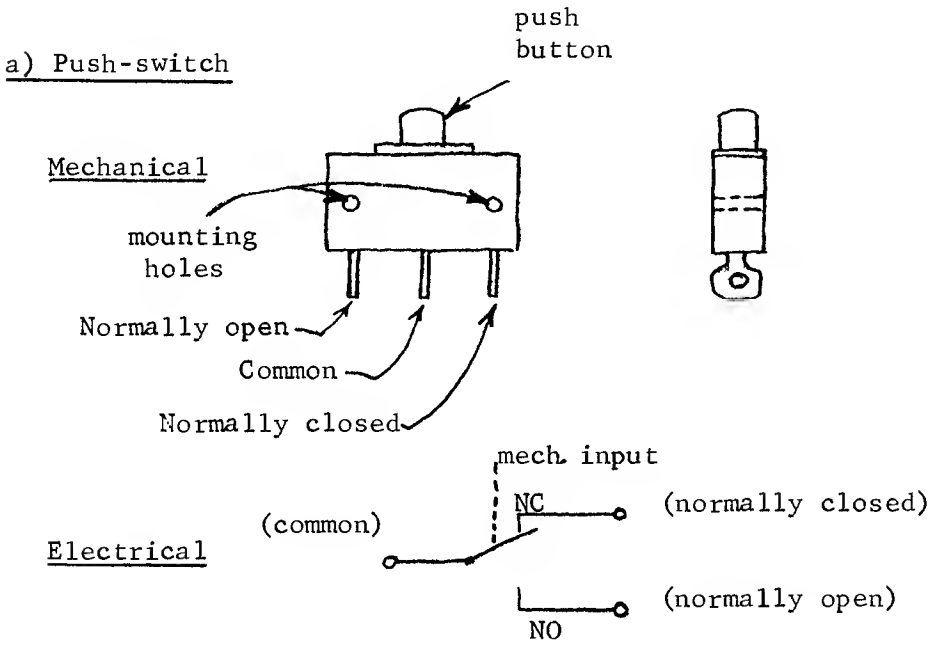


Figure 1. Principle of the new cycle timer

Upon reaching the "finish switch" and depressing its contact, the cycle would be complete and the motor would be turned off. The timer would then be ready for another cycle.

As will be shown later, Mr. Travaglio decided to use a geared down rotating plate to carry the rider, instead of using a lead screw. This allowed some mechanical simplifications and also provided for a rotary adjustment of the cycle duration - which is preferable from the human operator's point of view.

One of the most interesting aspects of the device is the switch circuitry which must be provided to give the desired action. A simple form of memory is also required and is accomplished with relays. The circuits will be described using the symbolism given in Figure 2.

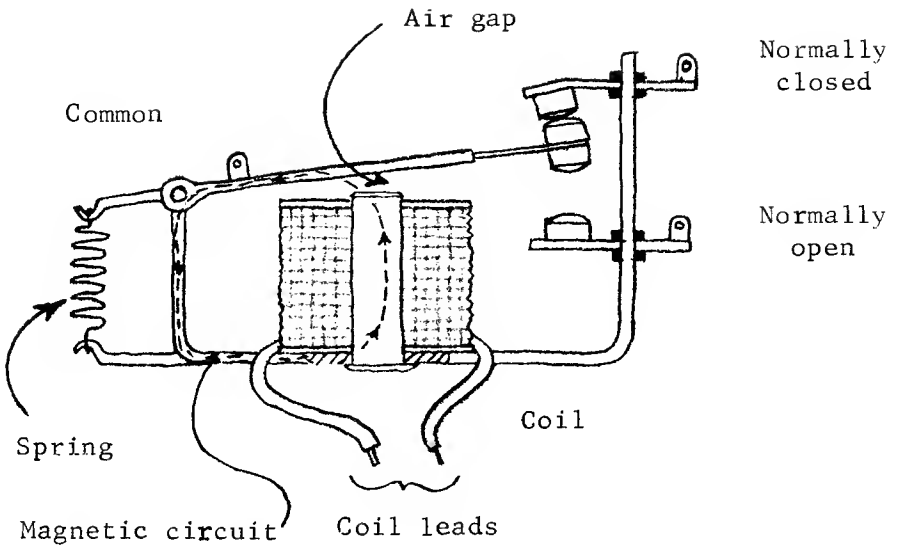


When the push-button is depressed, the switch conducts from the common terminal to the normally open terminal and the normally closed terminal is isolated. When the push-button is not depressed, the switch conducts from the common terminal to the normally closed terminal and the normally open terminal is isolated. During the action of depressing the button there is a brief time in which all the terminals are isolated.

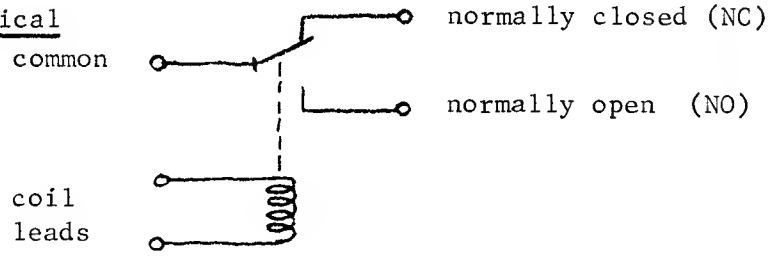
Figure 2a

b) Relay

Mechanical



Electrical



When the coil is energized (with either a.c. or d.c.) the energy in the magnetic circuit is less if the arm moves downward and decreases the size of the air gap. Therefore, the minimum energy principle indicates that when the coil is energized there will be a force pulling the arm closed. The electrical action of the relay is then identical to that of the push button switch, except that the magnetic circuit takes the place of the push-button.

Figure 2b

c) Multi-Contact Relays

On some relays, there are several sets of contacts which are insulated from one another. The electrical symbol for such a relay is shown below, where the dashed line indicates that the contacts are all controlled by the one coil.

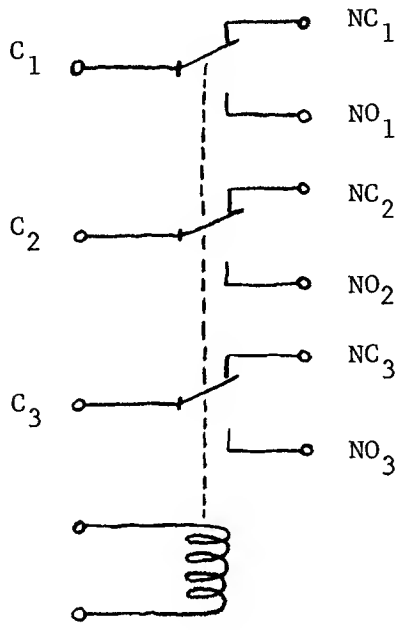


Figure 2c. Circuit components and symbols.

In order to understand the timer circuitry, it is helpful to study some simpler circuits which illustrate principles used in the timer. For example, the circuit shown in Figure 3 is a very simple circuit which has a kind of memory. Specifically, it remembers whether or not the push button has been depressed, since once the button is depressed, the relay contact closes and the relay keeps itself energized, even after the push button is released.

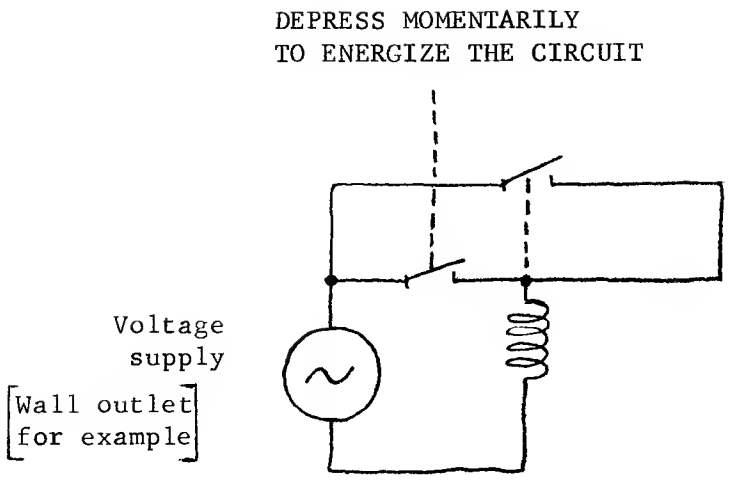


Figure 3. A self locking relay circuit.

A modification required to use this circuit in the timer is shown in Figure 4, where provision for unlocking the circuit is made. In this arrangement, the circuit remembers which button was pushed last.

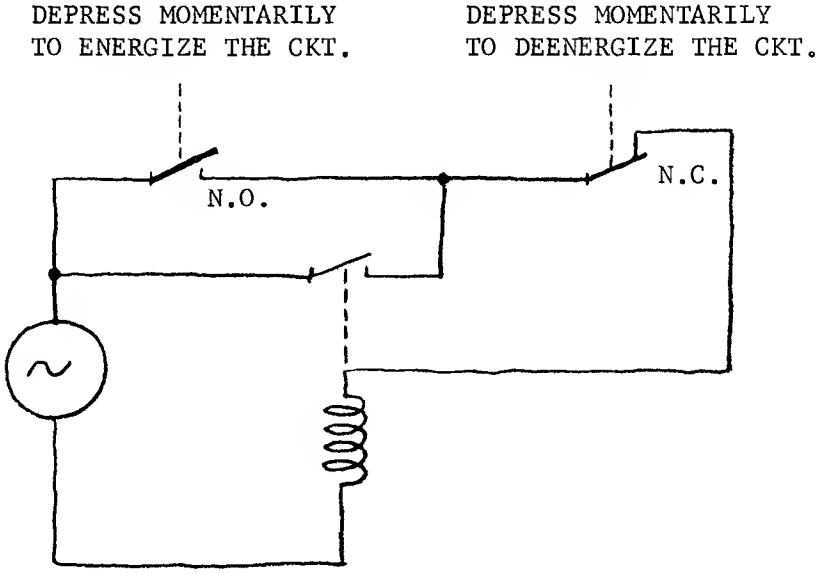


Figure 4. A circuit for push-button control of a relay

If a relay having several sets of contacts is used in the control circuit of Figure 4 a motor direction control circuit such as is needed in the timer is achieved. This is shown in Figure 5.

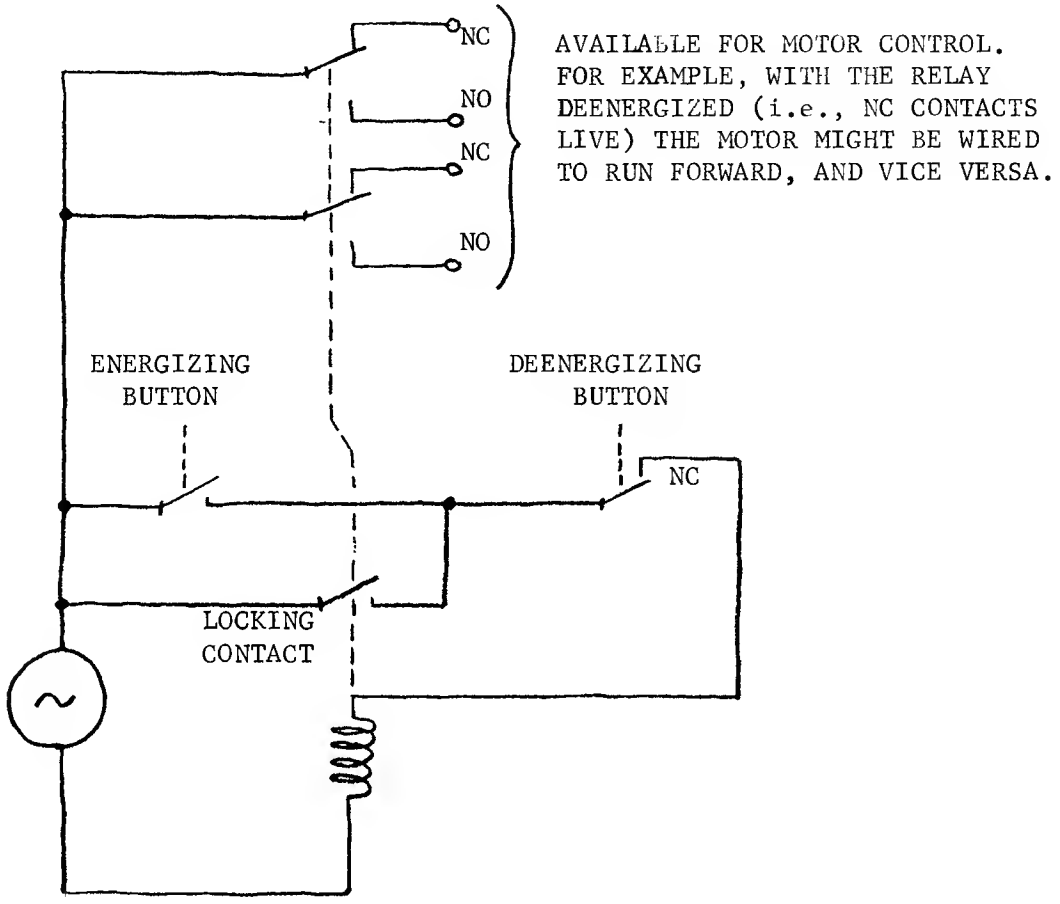


Figure 5. A motor direction control circuit

The actual circuit adopted by Mr. Travaglio is shown in Figure 6 and differs in some minor details from that shown above. For example, Mr. Travaglio chose to bring his motor power in through the push-button switches so that the power would be shut off as quickly as possible before reversing, thereby giving the motor a little extra time to reverse. Also, he has provided an on-off switch as would obviously be necessary.

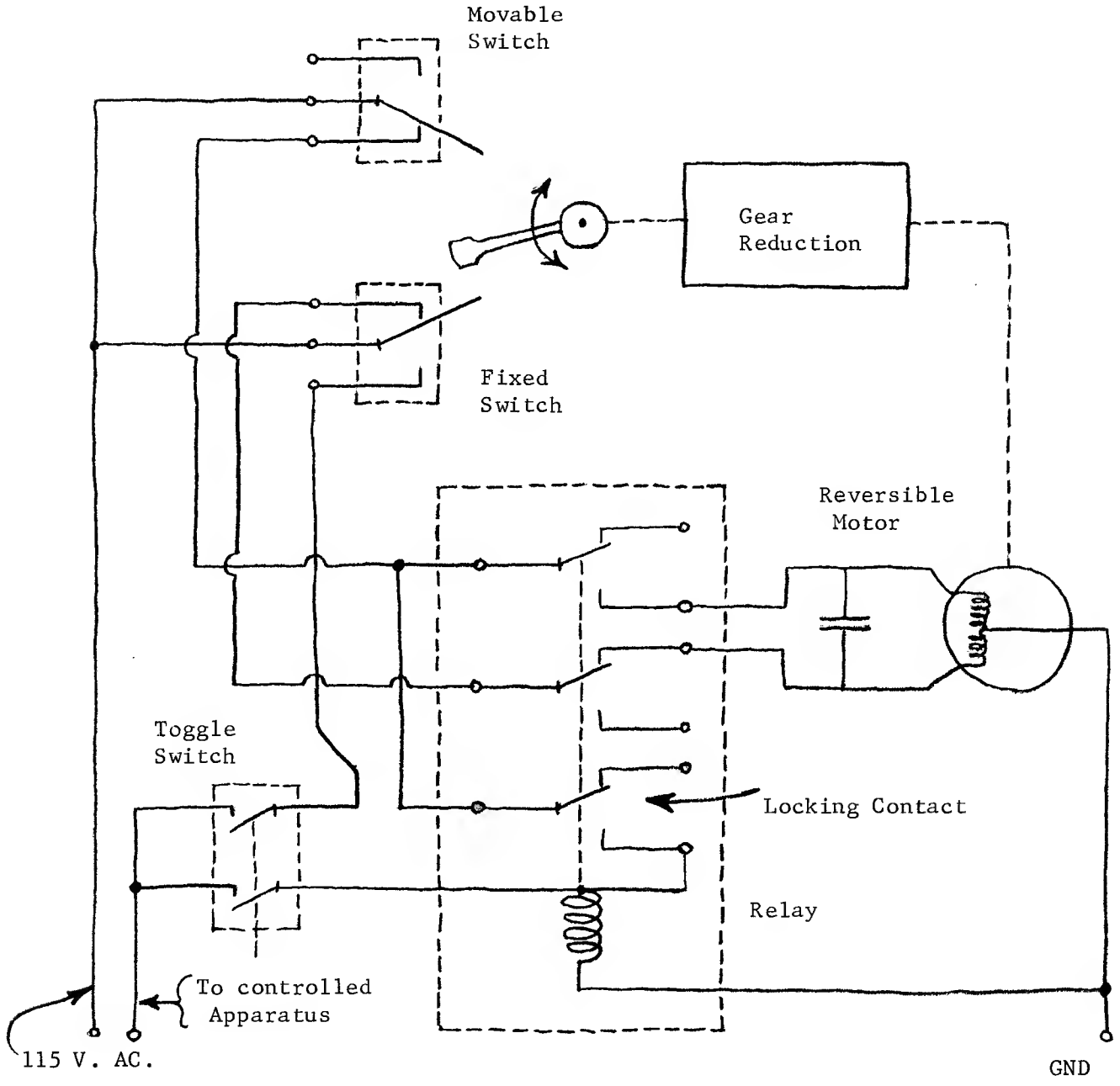


Figure 6. Timer Circuit used by Mr. Travaglio.

The essential mechanical details of the prototype time are shown in Figure 7. A selection of drawings of the prototype time follow.

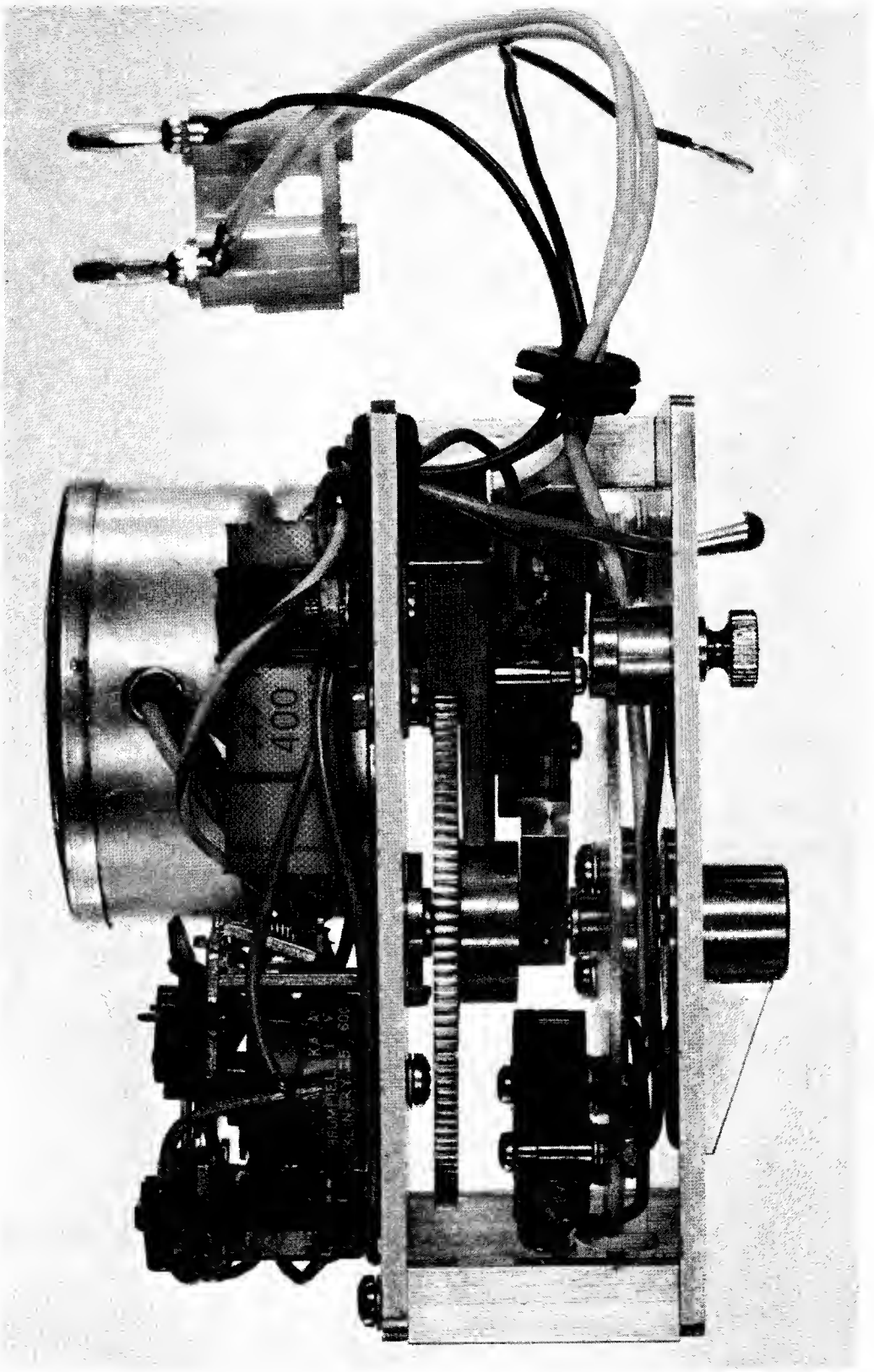
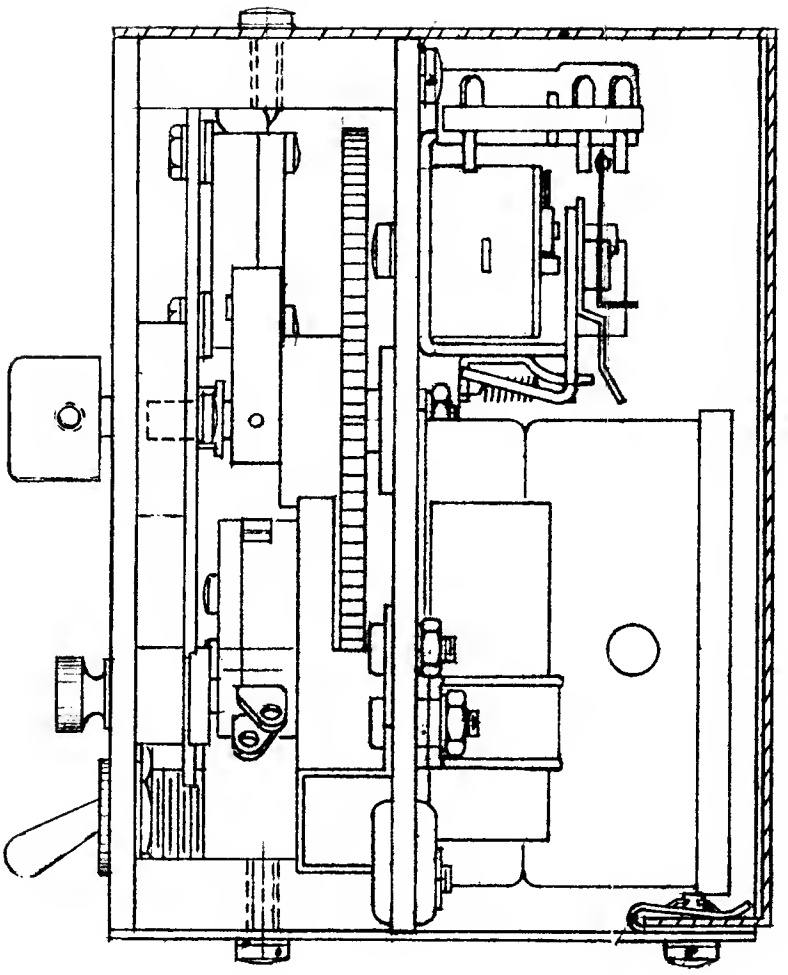
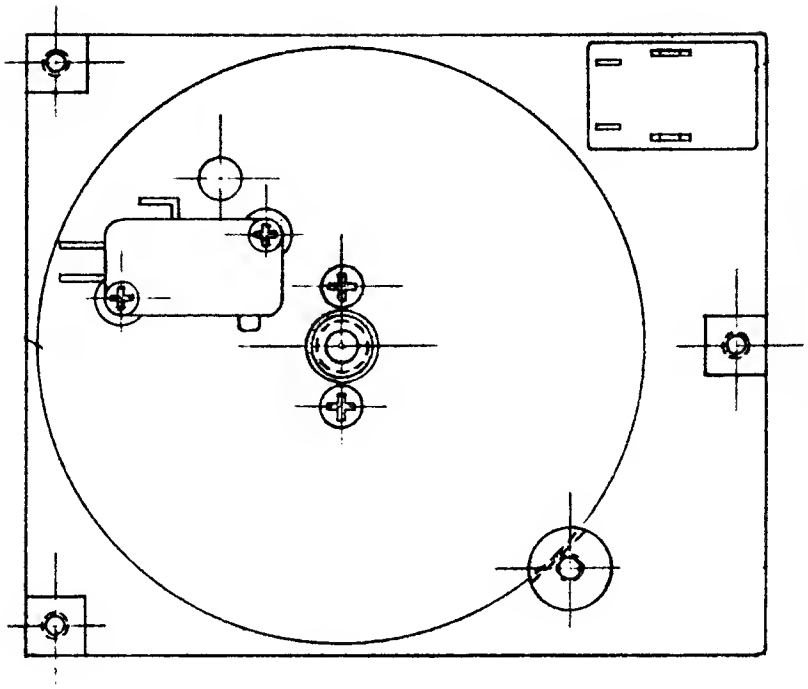


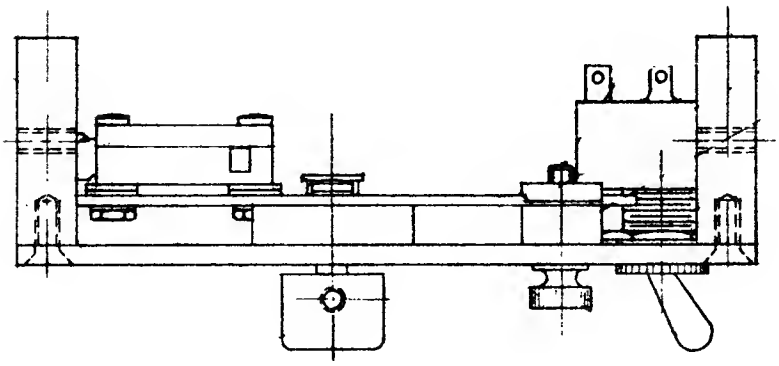
Figure 7.

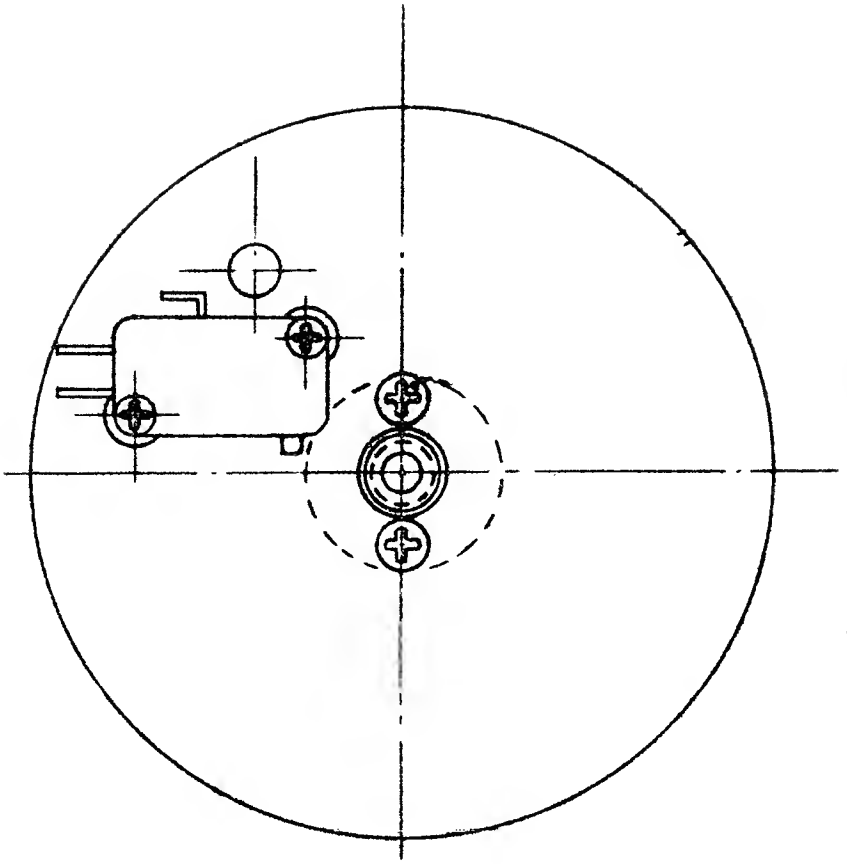


TIMER FINAL ASSEMBLY

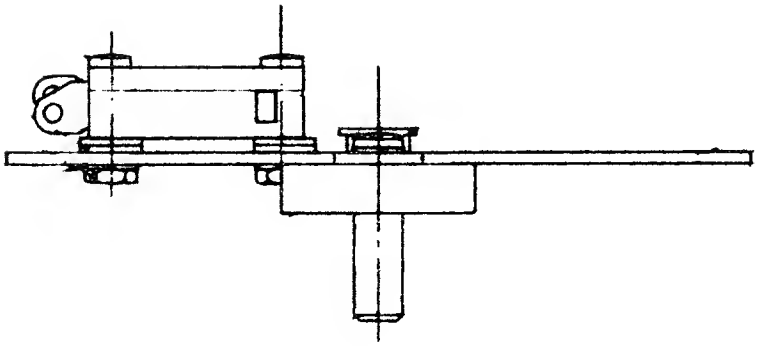


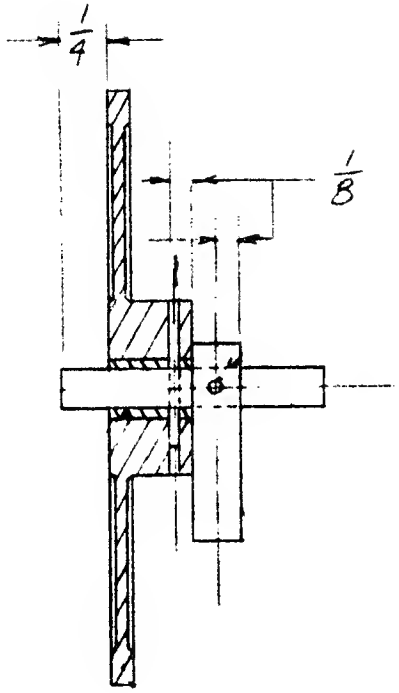
FRONT PLATE ASSEMBLY

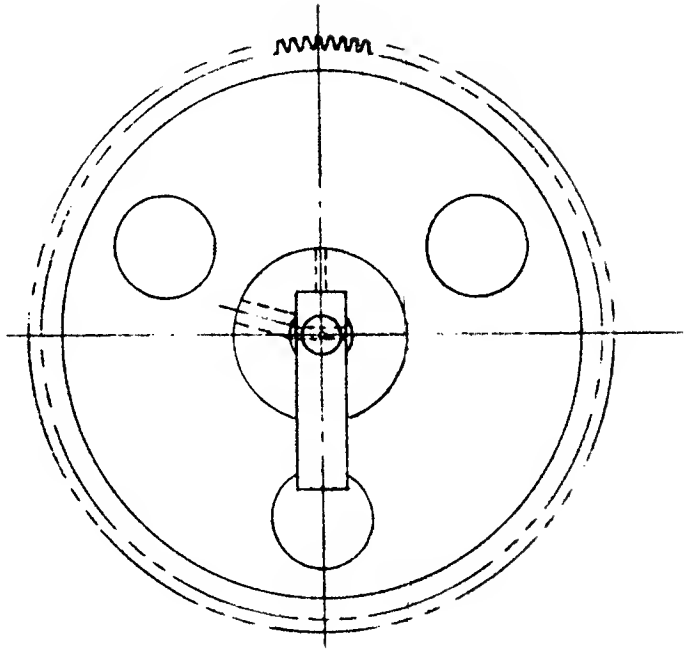




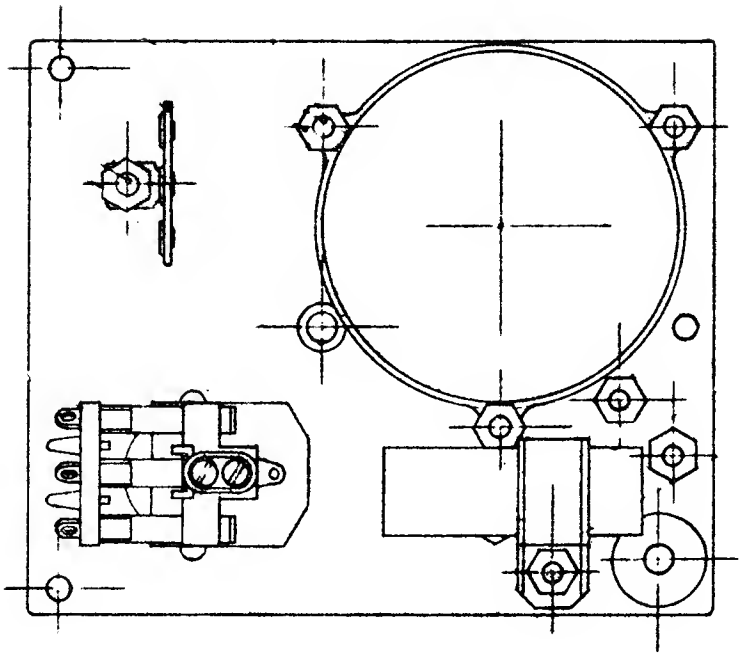
CLAMP PLATE ASSEMBLY







ACTUATOR DRIVE ASSEMBLY



BACK PLATE ASSEMBLY